Serial No. 09/697,570

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APPENDIX

VERSION WITH MARKINGS TO SHOW CHANGES MADE

The following is a marked-up version of the changes to the claims which are being made in the attached response to the Office Action dated May 31, 2001.

IN THE SPECIFICATION:

The paragraph beginning at page 1, line 9, and ending at page 1, line 17:

In recent years, actuators have been proposed having two displacement elements such as a piezoelectric element or the like are arranged with their displacement directions set at a predetermined angle (e.g., 90°). In this actuator, an alternating current voltage signal having a specific phase difference drives each displacement [elements] <u>element</u> such that a drive member provided at the intersection point of the displacement elements moves in an elliptical path. This drive member abuts a driven member, and rotates or moves the driven member in a specific direction. Such an actuator is referred to as a truss-type actuator.

The paragraph beginning at page 4, line 20, and ending at page 6, line 24:

These and other objects and features of the present invention will become apparent from the following description of the preferred embodiments thereof taken in conjunction with the accompanying drawings, in which:

FIG. 1 shows the structure of a laminate-type piezoelectric element;

FIG. 2 illustrates the relationship between the displacement (amount of distortion) of the piezoelectric element and the strength of the electric field generated between each electrode in the laminate-type piezoelectric element;

FIG. 3 shows the structure of a truss-type actuator using a laminate-type piezoelectric element;

FIG. 4 shows the block structure of the drive circuit;

FIG. 5a shows the path of the drive member of the actuator when the

FIG. 5a shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 0 degrees;

FIG. 5b shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 45 degrees;

FIG. 5c shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 90 degrees;

FIG. 5d shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is [180] 135 degrees;

FIG. 5e shows the path of the drive member of the actuator when the amplitudes of the drive signals applied to two piezoelectric elements are equal and the phase difference is 180 degrees;

FIG. 6a shows the path of the tip member when the actuator is under no load and a drive voltage of 30 V is applied;

FIG. 6b shows the path of the tip member when the actuator is under no load and a drive voltage of 40 V is applied;

FIG. 6c shows the path of the tip member when the actuator is under no load and a drive voltage of 50 V is applied;

FIG. 6d shows the path of the tip member when the actuator is under no load and a drive voltage of 60 V is applied;

FIG. 6e shows the path of the tip member when the actuator is under no load and a drive voltage of 70 V is applied;

FIG. 6f shows the relationship between the drive voltage and the diameter (displacement amount) of the path of the tip member;

FIG. 7 shows the relationship between the compression force applied by the spring of the actuator, and the contact interval between the tip member and the rotor;

FIG. 8 shows the relationship between the speed (rotation) and load on the rotor in the actuator;

FIG. 9 shows the actuator output characteristics (load-to-drive efficiency characteristics);

FIG. 10 shows the elastic contact model generating elastic deformation in the contact area of the tip member and the rotor in the actuator;

FIG. 11 shows the relationship between the displacement of the piezoelectric element and the drive force generated thereby in the elastic contact model;

FIGS. 12a, 12b, 12c, 12d show the deportment when the piezoelectric element extends and contracts in the elastic contact model;

FIG. 13 shows the relationship between the displacement of the piezoelectric element and the compression force in each state in the elastic contact model;

FIG. 14 shows the structure of another embodiment of a truss-type actuator;

FIG. 15 shows the voltages applied to the two piezoelectric elements of the actuator, and the displacement resulting therefrom;

FIG. 16 shows a voltage applied to the first piezoelectric element and the second piezoelectric element; and

FIGS. 17a, 17b, 17c, 17d, 17d, 17e illustrate the principle of rotating the rotor by an actuator.

The paragraph beginning at page 8, line 1, and ending at page 8, line 13:

When an alternating current drive voltage (AC signal) from the drive power source 16 is applied between the electrodes 12 and 13, the ceramic thin plates 11 repeatedly extend and contract in the same direction in accordance with the electric field, such that the entire piezoelectric element 10 repeatedly extends and contracts. The piezoelectric element 10 has an intrinsic resonance frequency determined by the electrical characteristics and structure of the piezoelectric element. When the frequency of the alternating current driver voltage and the resonance frequency of the piezoelectric element 10 match, impedance is reduced, and the displacement of the piezoelectric element 10 is increased. The piezoelectric element 10 desirably uses [the] this resonance phenomenon to drive

at low voltage for small displacement relative to the external dimensions of the piezoelectric element 10.

The paragraph beginning at page 11, line 6, and ending at page 11, line 19:

In FIG. 7, the vertical axis represents the contact ratio which is a ratio of the contact interval, during which the tip 20 is in contact with the rotor 40, to the entire time period, and the horizontal axis represents [the to] the compression force of the spring 41. When the voltage (drive signal amplitude) is 70 V, the contact interval between the tip 20 and the rotor 40 is near proportional to the compression force of the spring 41. When the voltage is 70 V, the amount of displacement of the piezoelectric elements 10 and 10' becomes large, and the speed of the tip 20 increases due to the elastic deformation speed (recovery speed) of the rotor 40 and tip 20 through the reaction force of the pressure applied by the spring 41, such that the tip 20 is completely separated from the rotor 40. As the compression force applied by the spring 41 increases, the recovery speed of the tip 20 and rotor 40 increases, and the time during which the tip 20 is separated from the rotor 40 becomes shorter.

The paragraph beginning on page 13, line 28, and ending on page 14, line 16:

The relationship between the displacement of the piezoelectric elements 10 and 10' and the drive force generated by such displacement is shown in FIG. 11. In the drawing, the vertical axis represents the amount of displacement X of the piezoelectric elements 10 and 10', and the horizontal axis represents the force F generated by the piezoelectric elements. Since the piezoelectric elements 10 and 10' are displaced only an amount X0 when a voltage V0 is applied to the piezoelectric elements 10 and 10', a force $F0=k2 \cdot X0$ is generated at the ends of the piezoelectric elements 10 and 10'. Conversely, in the state wherein a voltage is not applied to the piezoelectric elements 10 and 10', the weight W at that end of the element is such that weight W=F0, and the piezoelectric elements 10 and 10' are displaced only -X0 (contracts only X0). [The] Now assume a spring having a spring constant K is mounted in a state of free length to the piezoelectric elements

10 and 10'. When the amount of displacement when a voltage Vo is applied to the piezoelectric elements 10 and 10' is designated X, and the reaction force from the spring is designated F, the relationships F0=(K+k2)·X, and F=K·X are obtained [obtain]. When the value K is removed from these equations, the relationship X=(F0-F) is obtained [obtains].

The paragraph beginning at page 15, line 24 and ending at page 15, line 28:

The relationship of each constant is determined using FIGS. 12a~12d. The compression force in FIGS. 12b, 12c, 12d are designated N, N', N"; the displacement of each element is designated ΔXn, ΔXn', ΔXn" (where n=1~3). Since the total length of the system is unchanged in these states, the following relationship is obtained [obtains].

The paragraph beginning at page 16, line 9, and ending at page 16, line 10:

Similarly, when N, N', N" are substituted in the right side of equation (1), the following is obtained [obtains].

The paragraph beginning at page 16, line 13, and ending at page 16, line 14:

When N' is eliminated from equations (2) and (3), the following is obtained [obtains].

The paragraph beginning at page 16, line 16, and ending at page 16, line 19:

When the critical compression force of the spring 41 at the time of transition from the intermittent contact state to the normal contact state between the tip 20 and the rotor 40 is designated Nt, since N"=0, the following is obtained [obtains].

The paragraph beginning at page 16, line 21, and ending at page 16, line 24:

On the other hand, the amplitude Nw of the compression applied to the rotor 40 is normally constant in the normal contact state between the tip 20 and the rotor 40, such that from equation (3) the following <u>is obtained</u> [obtains].

The paragraph beginning at page 18, line 5, and ending at page 18, line 9:

Since the spring constant k3 of the rotor 40 changes depending on the surface roughness and hardness of the contact surface of the tip 20, <u>the contact surfaces</u> may be made smooth by polishing the surfaces of the tip 20 and rotor 40, and increasing the hardness of the surface by a nitriding process or oxidation process.

The paragraph beginning at page 18, line 21, and ending at page 19, line 2:

A first displacement element 60 and second displacement element [61] <u>60'</u> respectively comprise a single layer piezoelectric element (ceramic thin plate) 61 and 61', [and] <u>an</u> elastic body [61] <u>62</u>, 62', and electrodes are not provided on both surfaces of the piezoelectric elements 61 and 61'. The first displacement element 60 and the second displacement element 60' are attached to the tip 20 and base 30 by bolts 63 and 63' without using adhesive. The elastic bodies 62 and 62' and the base 30 are respectively formed of electrically conductive material, drive power sources 16 and 16' are connected between the elastic bodies 62, 62' and the base 30, so as to drive the first displacement element 60 and the second displacement element 60' at the previously described resonance frequency.

The paragraph beginning at page 20, line 22, and ending at page 20, line 26:

Accordingly, the actuator drive efficiency can be maximized and the actuator output can be simultaneously maximized by driving the displacement element <u>such that</u> the drive member and driven member are in a state of intermittent contact, and in a state near the condition of transition from the intermittent contact state to the normal contact state.

REMARKS

Supplementary Information Disclosure Statement Submission

Submitted concurrently with this Amendment is a Supplementary Information Disclosure Statement for the Examiner's consideration.

Foreign Priority

The acknowledgement, in the Office Action, of a claim for foreign priority under 35 U.S.C. § 119(a)-(d), and that the certified copy of the priority document has been received, is noted with appreciation.

Status Of Application

Claims 1-12 were pending in the application. The status of the claims is as follows:

Claims 2, 3, and 5-12 are rejected under the second paragraph of 35 U.S.C. § 112 as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention;

Claims 1, 4-7, and 10-12 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,947,077 to Murata (hereinafter "the Murata patent");

Claims 2 and 8 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the Murata patent in view of common knowledge in the art; and

Claims 3 and 9 are rejected under 35 U.S.C. § 103(a) as being unpatentable over the Murata patent in view of common knowledge in the art as applied to claims 2 and 8, and further in view of U.S. Patent No. 5,523,643 to Fujimura et al. (hereinafter "the Fujimura patent").

Drawings

The drawings are objected to because Figure 16, as referenced in the specification, is not present or is incorrectly numbered in the filed drawings.

A Request for Approval of Proposed Drawing Changes is submitted herewith for consideration by the Examiner. The proposal requests approval to change the designation of "FIG. 14" on the thirteenth sheet of the drawings to "FIG. 16" in order to correct the form of the drawings. Specifically two different figures were labeled as "FIG. 14", including the thirteenth sheet of the drawings which should have been labeled "FIG 16."

Amendments to the Specification

Amendments have been made to the specification to improve the form thereof. The Amendments include a description of FIG. 16 added to the BRIEF DESCRIPTION OF THE DRAWINGS according to the reference to FIG. 16 at page 1, lines 19-24. Also, the description of FIG. 5d was amended, and a description of FIG. 5e was added, each according to the description of FIGS. 5a-5e on page 10, lines 5-8.

Claim Amendments

Claims 1, 2, 5-8, 11 and 12 have been amended solely to improve the form thereof. In particular, the phrase "a compression member for pressing said drive member against the driven member" in claim 1 and claim 7 has been amended to "a compression member for pressing said drive member against the driven member such that the drive member and the driven member are in a state of intermittent contact under conditions near the condition of transition from the intermittent contact state to a normal contact state". Also, in claim 1 "drive circuit for driving said displacement element such that the drive member and the driven member are in a state of intermittent contact under conditions near the condition of transition from the intermittent contact state to a normal contact state" has been amended to "a drive circuit for driving said displacement element", and in claim 7 "a drive circuit for driving said first and second displacement elements such that the drive member and the driven member are in a state of intermittent contact under conditions near the condition of transition from the intermittent contact state to a normal contact state" has been amended to "a drive circuit for driving said first and second displacement

elements". Support for the amendment of claims 1 and 7 is set forth at page 12, line 10, to page 13, line 15.

Please note that the amendments to claims 1, 2, 5-8, 11, and 12 are not necessary to distinguish the present claims over the references.

35 U.S.C. § 112 Rejection

The rejection of claims 2, 3 and 5-12 under the second paragraph of 35 U.S.C. § 112, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention, is respectfully traversed based on the following.

In claim 2 "the spring constant of the compression member" is amended to --a spring constant of the compression member--, "the combined spring constant" is amended to --a combined spring constant--, "the spring constant of the driven member" is amended to --a spring constant of the driven member--, "the amount of displacement" is amended to --an amount of displacement--, and "the compression force" is amended to --a compression force--. Thus, both claim 2 and claim 3 now properly depend from claim 1.

In each of claims 5 and 6 the phrase "said displace element" is amended to --said displacement element--. Thus, each of claims 5 and 6 refers to a previously recited element of claim 1.

In claim 7, "a second displace element" is amended to --a second displacement element--; therefore, "the second displacement elements" recited in claims 8, 9, and 10 now properly refers to "a second displacement element" in claim 7.

Claim 8 is amended to provide for better antecedency. Specifically, "the spring constant of the compression member" is amended to --a spring constant of the compression member--, "the combined spring constant" is amended to --a combined spring constant--, "the spring constant of the driven member" is amended to --a spring constant of the driven member--, "the amount of displacement" is amended to

--an amount of displacement--, and "the compression force" is amended to --a compression force--.

In each of claims 11 and 12, the phrase "first and second displace elements" is amended to --first and second displacement elements--; therefore, claims 11 and 12 are now proper dependent claims.

Accordingly, it is respectfully requested that the rejection of claims 2, 3 and 5-12 under the second paragraph of 35 U.S.C. § 112, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention, be reconsidered and withdrawn.

35 U.S.C. § 102(b) Rejection

The rejection of claims 1, 4-7, and 10-12 under 35 U.S.C. § 102(b), as being anticipated by the Murata patent, is respectfully traversed based on the following.

Claim 1 and claim 7 each requires a compression member for pressing a drive member against a driven member such that the drive member and the driven member are in a state of intermittent contact under conditions near the condition of transition from the intermittent contact state to a normal contact state. This feature of claim 1 and claim 7 is not disclosed or suggested by the Murata patent.

Although the Murata patent does disclose an actuating device that is capable of displacing a moving part, as described in column 5, lines 8-15, column 9, lines 13-16, and column 10, lines 37-46, the Murata device is able to drive the moving part by a magnetic coupling arrangement, where the moving part is driven in a non-contact manner. Thus, the Murata patent does not disclose a compression member for pressing a drive member against a driven member such that the drive member and the driven member are in a state of intermittent contact under conditions near the condition of transition from the intermittent contact state to a normal contact state, because the Murata patent does not disclose a device that drives a moving part by contacting the moving part. Therefore, the Murata patent does not anticipate claim 1 and claim 7.